600 - TERRACES

Definition

An earthen embankment, channel, or a combination ridge and channel constructed across the slope.

Scope

This standard covers the planning and design of all types of terraces. It does not apply to diversions.

Purpose

To: (1) reduce slope length, (2) reduce erosion, (3) reduce sediment content in runoff water, (4) intercept and conduct surface runoff at nonerosive velocity to a stable outlet, (5) retain runoff for moisture conservation, (6) prevent gully development, (7) reform the land surface, (8) improve farmability, (9) reduce flooding, and (10) improve water quality.

Conditions Where Practice Applies

This practice applies where:

1. Water erosion is a problem.
2. There is a need to conserve water.
3. The soils and topography are such that terraces can be constructed and farmed with a reasonable effort.
4. A suitable outlet can be provided, or,
5. Runoff and sediment damages land or improvements downstream or impairs water quality.

Planned Considerations for Water Quantity and Quality

This practice reduces the slope length and the amount of surface runoff which passes over the area downslope from the terrace. Open end gradient terraces may cause a slight to significant decrease in surface runoff depending on field topography, terrace grade, and construction techniques. Storage terraces with underground outlets will retain runoff thus increasing infiltration, conserving soil moisture, cause deep percolation and increasing ground water recharge. Storage terraces may cause ground

water contamination from nitrates, pesticides and other contaminants. Following are additional planning considerations:

1. Terraces can be used to intercept storm runoff, shorten slope lengths, and be the guide to facilitate contour farming. Contour farming with the terrace may reduce surface runoff and increase infiltration and percolation to ground water.

2. Terraces with or without vegetation may trap sediment and prevent nutrient and pesticides from moving off the land.

3. Plowing and chiseling on the contour and leaving a rough surface will reduce runoff and loss of sediment, nutrients, and pesticides.

4. In addition to terraces, diversions, grassed waterways, underground outlets, water and sediment control basins, field borders, and filter strips may be needed with terraces to adequately control concentrated flow erosion.

5. Areas disturbed by terrace construction need to have a liberal application of fertilizer and lime, be deep plowed, and be planted to a nurse crop to improve soil tilth and crop production.

6. Grassed terraces will provide habitat (cover and food) for wildlife.

Spacing

The maximum spacing of terraces for erosion control shall be determined by one of the following methods:

1. $V.I. = xs + y$ or $H.I. = (xs + y)\frac{100}{s}$

Where: V.I. = vertical interval in feet (m)

H.I. = horizontal interval in feet (m) (See Figures 1 and 2)

x = a variable with values from 0.4 to 0.8 (0.12 to 0.24)

s = land slope in percent

y = a variable with values from 1.0 to 4.0 (0.3 to 1.2)

The value of x for Alabama is 0.5 (0.15) for all counties north of the line created by the south boundaries of Lamar, Tuscaloosa, Bibb, Chilton, Coosa, Tallapoosa, and Chambers Counties. The value of x is 0.4 (0.12) for all counties south of this line. Use 0.4 statewide Values of y are influenced by soil erodibility, cropping system, and crop management practices. A value of 1.0 (0.3) should be selected for easily erodible

soils with tillage systems that provide little or no cover during periods of intense rainfall. A value of 4.0 (1.2) should be used for erosion resistant soils with tillage systems that leave a large amount of cover (1.5 tons of straw equivalent per acre or 3.4 metric tons per hectare) on the surface. A value of 2.5 (.75) should be used where one of the above factors is favorable and the other unfavorable. Other values between 1.0 (0.3) and 4.0 (1.2) may be used according to the estimated quality of the above factors. The horizontal spacing does not have to be less than 90 feet (27m) as shown in Table 600-1.

2. Table: 600-1

	Allowable Spacing for Terrace for Conditions[1/]					
	Good		Average		Poor	
Average Land Slope In Feet Per 100 Feet	X = 0.4 (0.12) Vertical Interval Feet (m)	Y = 4.0 (1.2) Horizontal Interval Feet (m)	X = 0.4 (0.12) Vertical Interval Feet (m)	Y = 2.5 (0.75) Horizontal Interval Feet (m)	X = 0.4 (0.12) Vertical Interval Feet (m)	Y = 1.0 (0.3) Horizontal Interval Feet (m)
1 or less	4.4 (1.30)	440 (132)	2.9 (0.87)	290 (87)	1.4 (0.42)	140 (42)
2	4.8 (1.45)	240 (72)	3.3 (1.00)	175 (52)	1.8 (0.54)	90 (27)
3	5.2 (1.56)	173 (52)	3.7 (1.11)	123 37)	2.2 (0.66)	73* (22)
4	5.6 (1.68)	140 (42)	4.1 (1.23)	103 (31)	2.6 (0.78)	65* (20)
5	6.0 (1.80)	120 (36)	4.5 (1.35)	90 (27)	3.0 (0.90)	60* (18)
6	6.4 (1.92)	107 (32)	4.9 (1.47)	82* (25)	3.4 (1.02)	57* (17)
7	6.8 (2.04)	97 (29)	5.3 (1.59)	76* (23)	3.8 (1.14)	54* (16)
8	7.2 (2.16)	90 (27)	5.7 (1.71)	71* (21)	4.2 (1.26)	53* (16)

* Spacing does not have to be less than 90 feet (27m).
[1/] See Table 600-1 for terrace spacing and number of rows.

3. The Universal Soil Loss Equation (USLE) - The spacing shall not exceed the slope length determined (for contour cultivation) by using the allowable soil loss, the most intensive use planned, the expected level of management, and the terrace p factor (Table 600-2). (See Technical Guide Section III-1-B for data and examples of use.)

These maximum limits (Table 600-3) may not be exceeded when making adjustments as indicated below. Spacing may be increased as much as 10% to provide better alignment or location, to adjust for farm machinery, or to reach a satisfactory outlet. Spacing may be increased an additional 10% for terraces with underground outlets. The spacing should be adjusted to provide for an even number of trips for anticipated row crop equipment and maximum opportunity for changing row widths. Risers for underground outlets shall be placed uphill from the terrace ridge a distance equal to a multiple of the equipment width for 6 or 8 row equipment with all terrace intervals in multiples of 12 rows (12-48). The likelihood of benching of steep slopes by tillage, land forming, and erosion should be considered when determining the terrace interval.

For Level Terraces used for Erosion Control and Water Conservation, the spacing shall be determined as above except the maximum horizontal spacing may not exceed 600 feet (180m). An “x” value of 0.8 (0.24) may be used for all level terraces used primarily to impound water. Figures 1 and 2 show the horizontal interval or erosion length to be used in calculating terrace spacing in Figure 3.

For terraces on noncropland, the maximum spacing shall be governed by the capacity requirements.

Table 600-2 - Terrace P factors

Horizontal interval (ft)	Horizontal interval (m)	Closed outlets[1/]	Open outlets, with percent grade of --[2/] 0.1 - 0.3	0.4 - 0.7	0.8
Less than 110	Less than 33	.05	0.6	0.7	1.0
110 - 140	33 - 42	0.6	0.7	0.8	1.0
140 - 180	43 - 54	0.7	0.8	0.9	1.0
180 - 225	55 - 68	0.8	0.8	0.9	1.0
225 - 300	68 - 90	0.9	0.9	1.0	1.0
More than 300	More than 90	1.0	1.0	1.0	1.0

NOTE: If contouring or stripcropping P factors are appropriate, they can be multiplied by the terrace P factor for the compost P factor.

[1/] “P” factors for closed outlet terraces also apply to terraces with underground outlets and to level terraces with open outlets.

[2/] The channel grade is measured on the 300 ft (90 meters) of terrace or the one-third of total terrace length closest to the outlet, whichever distance is less.

Table 600-3 - Maximum permissible horizontal spacing for terraces.

Slope	USLE R factor 0 -35		35 - 175		175 & up		With contour stripcropping		For concentrated flow control	
percent	ft	m	ft	m	ft	m	ft	m	ft	m
0 - 2	700	210	500	150	450	130	600	180	700	210
2 - 4	700	210	400	120	300	90	600	180	700	210
4 - 6	600	180	400	120	200	60	600	180	600	180
6 - 9	400	120	300	90	150	45	400	120	500	150
9 - 12	400	120	250	75	150	45	250	75	500	150
12 - 18	250	75	200	60	150	45	150	45	400	120
18 up	250	75	200	60	150	45	150	45	300	90
Minimum spacing required, all slopes	200	60	150	45	90	27	90	27	200	60

Alignment

Terraces shall be parallel if feasible and as parallel as practicable in all cases. Curves should be long and gentle to accommodate farm machinery. Land forming, extra cut or fill along the terrace line, multiple outlets, variations in grade, channel blocks, and other methods are to be used to achieve good alignment. Field efficiency may be used to compare alternative terrace systems. Field efficiency is the ratio of time required to farm a rectangular field of the same acreage 1/2 mile (0.8 km) long. (See engineering reference material Eng. Ref. 11-9.)

Capacity

The terrace shall have enough capacity to control the runoff from a 10-year frequency, 24-hour storm without overtopping. (See Alabama Engineering field Manual (AEFM) for storm frequency values.) The capacity of storage terraces with underground outlets, shall be increased by the estimated 10-year sediment accumulation unless provisions are made to maintain the design capacity through maintenance. Terrace systems designed to provide flood protection or to function with other structures shall have capacity to control a storm of a frequency consistent with the potential hazard involved. When the capacity is determined by the formula Q = AV and the V is calculated by using Manning's Formula, an "n" value of 0.06 shall be used for bare channels and SCS-TP-61, Handbook of Channel Design for Soil and Water Conservation or equivalent, shall be used for vegetated channels.

"Each storage terrace in a system does not have to be individually designed. The design for a system of storage terraces may be based on the height of the terrace with the largest watershed with:

1. A height sufficient to meet cross-section requirements for terraces that bypass onto a grassed waterway or disposal area.

2. A height based on the steepest average slope and channel grade for terraces which store and release the design storm through underground outlets."

Cross Section

The cross section for standard gradient terraces shall be proportioned to fit the land slope, the crops grown, and the farm machinery used. Additional height shall be added if necessary to provide for settlement, channel sediment deposits, ridge erosion, the effects of normal tillage operations and safety. The ridge shall have a minimum width of 3 feet (1.0 m) at the design elevation. The minimum cross sectional area of the terrace channel for gradient terraces shall be as follows:

1. For slopes up to and including five percent
   Settled - 8 square feet (2.42 m^2)
   Newly constructed - 9 square feet

2. For slopes above five percent
   Settled - 7 square feet (2.1 m^2)
   Newly constructed - 9 square feet (2.72 m^2)

The minimum slope of vegetated front or back slope is 2:1. If necessary, steeper slopes may be used for special purposes but must be stable.

The opening at the outlet end of gradient and open-end level terraces shall have a cross section equal to that specified for the terrace channel.

For channel-type terraces constructed for two row equipment the minimum horizontal distance measured from the top of the ridge to the bottom of the channel shall be 7 feet (2.1), and the minimum distance from the top of the ridge to the lower side of the terrace shall be 7 feet (2.1); giving a minimum base width of 14 feet (4.2).

For channel type terraces constructed for multi-row equipment the minimum horizontal distance measured from the top of the ridge to the bottom of the channel and from the top of the ridge to the lower side of the terrace shall be consistent with the spacing required for the row equipment used but shall be not less than 13 feet (3.9); therefore, the minimum base width shall be 26 feet (7.9).

Ridge type terraces shall have a minimum (1) base width of 10 feet, (2) top width of 3 feet, and (3) settled height (vertical measurement) of 1 foot from the ground surface

above the terrace to the top of the terrace ridge. The constructed height shall be 1.2 feet (0.36) to allow for settlement.

The design height of the storage terrace shall be increased by the amount needed to insure that the design top elevation will be maintained after all settlement has taken place. The design height shall include a minimum of 0.5 foot for freeboard and settlement.

With a given height it will be necessary to compute the storage. Storage may consist of natural storage, excavated storage, or both. Tables in Chapter 8 of the Alabama Engineering Field Manual (AEFM) are recommended for use in computing the storage. Available computer programs may be used to calculate available storage (see AEFM). The use of natural storage allows for securing construction material from surrounding areas including old terraces and ridges.

End Closures

Level terraces may have open ends, partial end closures or complete end closures. Partial and complete end closures will be used only on soils and slopes where the stored water will be absorbed by the soil without appreciable crop damage or where underground outlets are provided.

When terraces with closed or partially closed ends are specified, the end closures must be installed before the terraces are considered complete. The end closures should be designed so the water will flow over the end closure before overtopping the terrace ridge.

Partial end closures shall not be more than half the effective height of the terrace ridge. Full end closures are those more than half the height of the ridge. The cross section of the closures may be less than the terrace cross section.

Channel Grade

Channel grade shall be determined by one of the following methods:

1. Maximum channel grade to the lower reaches of the channel should not exceed 0.6 feet per 100 feet (0.6 percent) of length.

2. Maximum channel velocity for farmed channels shall be nonerosive for the soil and planned treatment. Maximum velocity for erosion resistant soils is 2.5 ft/sec (0.75 m/sec), for average soils 2.0 f/sec, (0.6 m/sec), and for easily erodible soils 1.5 ft/sec (0.45 m/sec). Velocities are to be computed by Manning's formula using an "n" value of 0.035.

3. Maximum channel velocities for permanently vegetated channels shall not exceed those used for grassed waterways.

Channel grades may be uniform or variable. Channel velocity shall not exceed that which is nonerosive for the soil and planned treatment. Vegetation will be recommended and established in the terrace channel when the grade and velocity exceed the allowable. When terraces have an underground outlet, water and sediment will be ponded in the channel thus reducing velocities and allowing steeper channel grades near the outlet. Minimum grades are to be such that pounding in the channel due to minor irregularities will not cause serious damage to crops or delay field operations.

Terrace Lengths

The volume of water stored in level terraces is proportional to the length. Therefore, it is necessary that the length be held within reason so that damage in case of a break will be minimized. Level terrace length shall not exceed 3,500 feet (1060m) unless the channel is blocked at intervals not exceeding 3,500 feet (1060m). Gradient terrace length will normally be controlled by capacity and the nonerosive velocity requirement.

Outlets

All terraces must have adequate outlets. the outlet may be a natural or constructed grassed waterway, vegetated disposal area, or underground outlet. Vegetated outlets are to be installed before terrace construction. All outlets must convey water to a point where the discharge will not cause damage. See standard 412 for policy on stable outlet as follows:

1. Vegetated outlets may be used for gradient or open end level terraces. Such an outlet may be a grassed waterway or vegetated disposal area. The outlet must convey runoff water to a point where the outflow will not cause damage. Outlets are to be installed and vegetated before terrace construction to provide a stable nonerodible outlet or to insure establishment of vegetative cover. The water surface in the terrace shall not be lower than the water surface in the outlet at their junction when both are operating at design flow.

2. Underground outlets may be used on gradient or level terraces. The outlet consists of an intake and underground conduit. An orifice plate, an increase in conduit size, or other feature, shall be installed in each inlet as needed to control the release rate and prevent excessive pressure when more than one terrace discharges into the same conduit. The discharge, when combined with the storage, shall be such that a 10-year frequency, 24-hour storm will not overtook the terrace and growing crops will not be damaged significantly by standing water. The release time shall not exceed 48 hours for the design storm. Shorter periods may be necessary for some crops depending on soil characteristics and water tolerance of crops to be grown.

   The underground conduit shall meet the requirements specified in FOTG Standard 620 - Underground Outlet or in 606 Subsurface Drain. Conduits must be installed

deep enough to prevent damage from tillage equipment. The inlet shall consist of a vertical perforated pipe of a material suitable for the intended purpose. The inlet should be located uphill of the front slope of the terrace ridge to permit passage of farm machinery and, where necessary, to provide for the anticipated accumulation of sediment and subsequent raising of the terrace ridge. The outlet of the conduit shall have adequate capacity for the design flow without causing erosion. Blind inlets may be used where they are effective, usually in well-drained soils.

3. Soil infiltration may be used as the outlet for level terraces. Soil infiltration must permit draining the design storm from the terrace channel in a period so that growing crops are not significantly damaged by standing water.

Combinations of different types of outlet may be used on the same system to maximize soil and water conservation and to provide for economical installation of a more farmable system.

Combination

The surface layer of soils will be salvaged and spread back over cut areas where construction of terraces and outlet removes all of the surface soil and prevents establishment of good vegetation or significantly reduces crop production

Safety Operations and Maintenance

A program shall be established for maintaining terrace capacity, storage, ridge height, and outlets. Intakes for underground outlets must be kept clean and sediment buildup redistributed so that the inlet is in the lowest place. Inlets damaged or cut off by farm machinery must be replaced or repaired immediately.

Terrace ridges, especially those with steep back slopes, can be very hazardous. For this reason, some farmers prefer steep front slopes also, thus keeping machinery away from the steep back slopes. All cut and fill slopes that are to be farmed must be no steeper than those on which farm equipment can operate safely. Any hazards must be brought to the attention of the responsible person.

Vegetation

All steep back slope terraces (and steep front slope, if used) shall be vegetated as soon as practicable after construction. The sod shall be maintained and trees and brush controlled by chemical or mechanical means.

Plans and Specifications

Plans and specifications for installation of terraces shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

References

Alabama Engineering Field (Design) Manual for Conservation Practices.
Engineering Reference 11-9.
National Engineering Field Manual for Conservation Practices.
SCS-TP-61 Handbook for Channel Design for Soil and Water Conservation Practices.

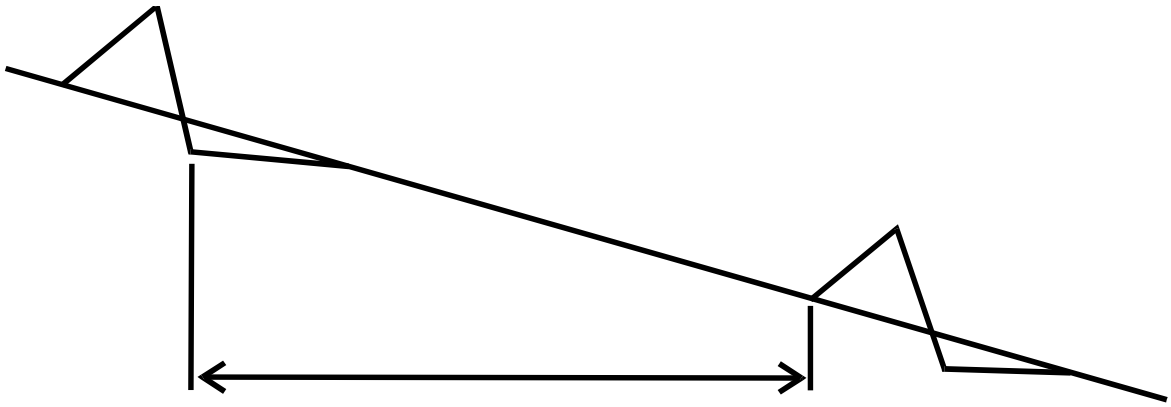

Figure 1 - Horizonal interval for steep back slope terraces.

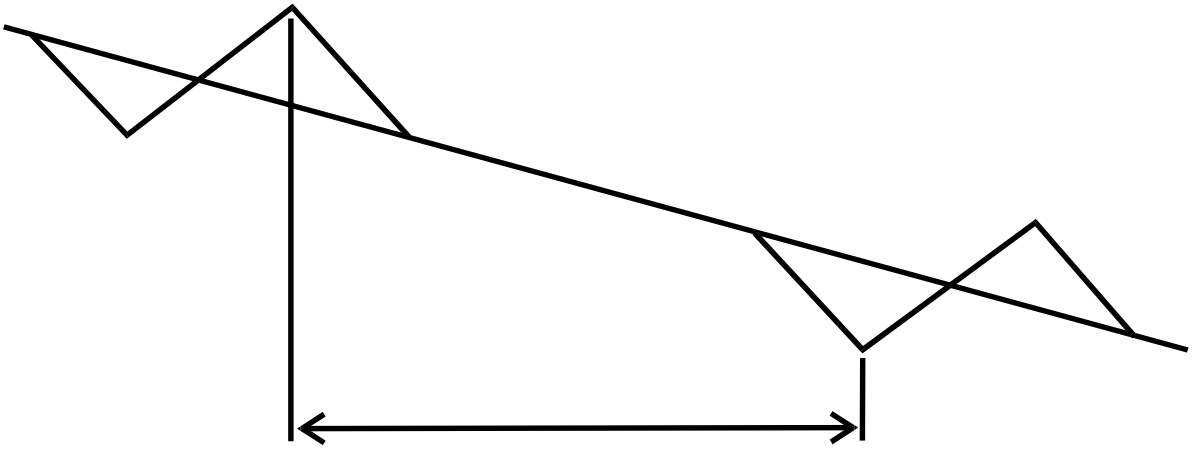

Figure 2 - Horizontal interval for broad-based terraces.

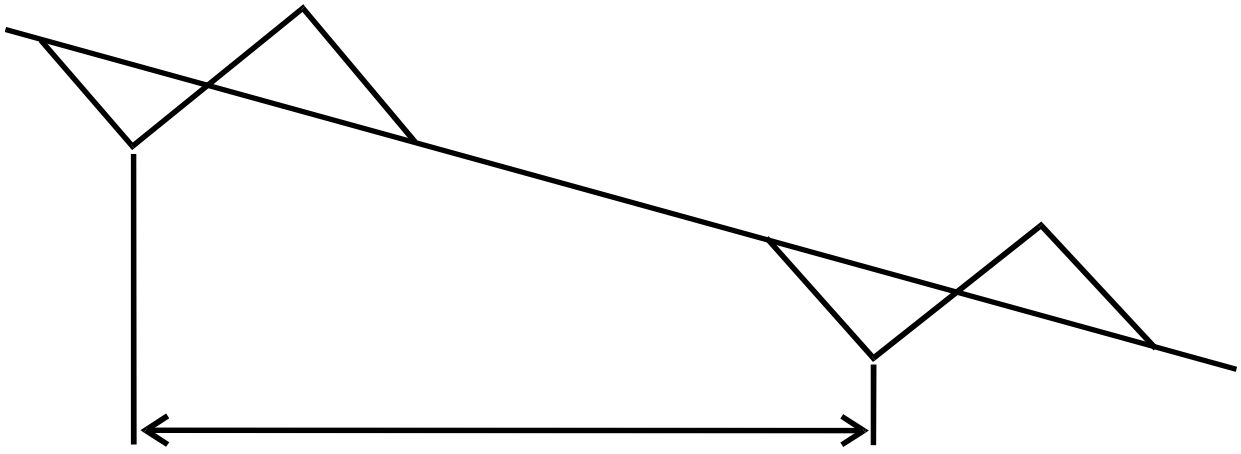

Figure 3 - Terrace spacing.

Table 600-4 - Parallel Terrace Spacing and Number of Rows Between Terraces

No. Rows	24	36	48	60	72	84	96	108	120	132	144	156	168
No. Trips 2-Row Equip	12	18	24	30	36	42	48	54	60	66	72	78	84
No. Trips 4-Row Equip.	6	9	12	15	18	21	24	27	30	33	36	39	42
No. Trips 6-Row Equip.	4	6	8	10	12	14	16	18	20	22	24	26	28
Distance Between Rows	Horizontal interval in feet, measured as shown in Figure 1 & 2												
20”	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0	240.0	260.0	280.0
22”	44.0	66.0	88.0	110.0	132.0	154.0	176.0	198.0	220.0	242.0	264.0	286.0	308.0
24”	48.0	72.0	96.0	120.0	144.0	168.0	192.0	216.0	240.0	264.0	288.0	312.0	336.0
26”	52.0	78.0	104.0	130.0	156.0	182.0	208.0	234.0	260.0	286.0	312.0	338.0	364.0
28”	56.0	84.0	112.0	140.0	168.0	196.0	224.0	252.0	280.0	308.0	336.0	364.0	392.0
30”	60.0	90.0	120.0	150.0	180.0	210.0	240.0	270.0	300.0	330.0	360.0	390.0	420.0
32”	64.0	96.0	128.0	160.0	192.0	224.0	256.0	288.0	320.0	352.0	384.0	416.0	448.0
34”	68.0	102.0	136.0	170.0	204.0	238.0	272.0	306.0	340.0	374.0	408.0	442.0	476.0
36”	72.0	108.0	144.0	180.0	216.0	252.0	288.0	324.0	360.0	396.0	432.0	468.0	
38”	76.0	114.0	152.0	190.0	228.0	266.0	304.0	342.0	380.0	418.0	456.0		
40”	80.0	120.0	160.0	200.0	240.0	280.0	320.0	360.0	400.0	440.0	480.0		
42”	84.0	126.0	168.0	210.0	252.0	294.0	336.0	378.0	420.0	462.0			
44”	88.0	132.0	176.0	220.0	264.0	308.0	352.0	396.0	440.0	484.0			
46”	92.0	138.0	184.0	230.0	276.0	322.0	368.0	414.0	460.0				

Example of Use - For 4-6-and 8-row equipment, find the maximum number of 36-inch rows that can be laid out within a terrace interval of 123 or 175 feet (for 2 percent land, average condition). Enter the table at the left on the 36-inch distance line and move horizontally to the largest spacing shown that is within the 175 feet maximum spacing. This is found to be 144 feet.

CONSTRUCTION SPECIFICATIONS

FOR

600 - TERRACES

Scope

This work shall consist of the excavation, shaping, and the filling necessary for the construction of the specified terraces on an acceptable spacing and grade. Construction operations shall be done in such a manner that erosion, water, air, and noise pollution will be minimized and held within limits as established by state regulations.

Obstruction Removal

All dead furrows, ditches, rills, or gullies to be crossed shall be filled before terrace construction or as a part of terrace construction. All old terraces, stumps, head rows, fence rows, or other obstructions that will interfere with the successful operation of the system shall be removed before terrace construction begins.

Alignment Grade and Spacing

The terraces shall be constructed to planned alignment, grade, and cross section, with the specified overfill for settlement and the channel graded to drain reasonably well.

Any ditch or depression at the bottom of the back slope should be filled and smoothed so that drainage will be away from the terrace and not parallel to it.

Provisions must be made where underground conduits are located under terrace ridges to prevent piping. Mechanical compaction, water packing, trench side wall sloping, and installation and backfill of conduit trenches far enough in advance to allow adequate settlement are methods that can be used. The materials used for the inlet and conduit will be suitable for the purpose intended (See Practice Standard 606). Terrace ridges constructed across gullies or depressions shall be compacted by machinery travel or other means sufficient to insure proper functioning of the terrace. The surface of the finished terrace shall be reasonably smooth and accommodate ordinary farm equipment. Storage terraces will be constructed with a minimum of 0.5 foot (0.15) for settlement and freeboard.

Where necessary, topsoil is to be stockpiled and spread over excavations and other areas to facilitate restoration of productivity.

Where vegetation is required, seedbed preparation, seeding, fertilizing, and mulching shall comply with the technical guide for critical area planting.

Safety and Maintenance

A program shall be developed for maintaining terrace capacity, storage, ridge height, and the outlets. Each intake of underground outlets must be kept clean and sediment buildup redistributed so the inlet is in the lowest place. Inlets damaged or cut off by farm machinery must be replaced or repaired immediately.

Terrace ridges, especially those with steep backslopes, can be very hazardous. For this reason some farmers prefer steep front slopes thus keeping machinery away from the steep back slopes. All cut and fill slopes that are to be farmed must be no steeper than that on which farm equipment can operate safely. Any apparent hazards must be brought to the attention of the responsible person.